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APRIL 1989

ACADEMIC MEDICINE

JOURNAL OF THE ASSOCIATION OF AMERICAN MEDICAL COLLEGES

Residents' Hours and Supervision
The Future of Medical Schools
Sex Differences in Rank Attainment
Geographic Medicine: A New Movement
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A Survey of U.S. Medical Physiology Curricula
A Review of Medical Education Informatics
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Deficiencies in Transfusion Medicine Education
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National Policy Perspectives
Editorial: Regulating Hospital-based Medical Education

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ASSOCIATION OF
AMERICAN MEDICAL
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PUBLISHER: Hanley & Belfus, Inc.
210 South 13th Street
Philadelphia, PA 19107

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ACADEMIC MEDICINE

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Academic Medicine (ISSN 1040-2446) is owned by the Association of American Medical Colleges, One Dupont Circle, N.W., Washington, DC 20036, and published monthly by Hanley & Belfus, Inc., 210 South 13th Street, Philadelphia, Pennsylvania 19107. Second-class postage paid at Washington, DC and additional mailing offices.

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Subscription rates: U.S., Canada, Latin America—$60.00 per year and $7.00 per single copy ($30.00 per year for students); all other locations—$70.00 per year and $8.00 per single copy.

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Advertising: Diane Sherel, Advertising Manager, Hanley & Belfus, Inc., 210 South 13th Street, Philadelphia, PA 19107; (215) 546-0313.
Subscriptions and changes of address: Membership and Publication Orders, AAMC, One Dupont Circle, NW, Washington, DC 20036; (202)828-0416.
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Sex Differences in Rank Attainment among Radiology and Internal Medicine Faculty

THOMAS H. DIAL, Ph.D., JANET BICKEL, M.A., and ANN M. LEWICKI, M.D.

Abstract—Overall, the percentage of women attaining the ranks of associate professor and professor remains well below the percentage of men in those ranks. Few studies of women in academic medicine have been conducted that might guide the leaders of medical schools and specialty societies in addressing the reasons for this disparity. The Association of American Medical Colleges (AAMC) Faculty Roster System allows comparison of a cohort of faculty at any selected time following their first faculty appointments. This study examined men and women faculty who received their first appointments in the departments of radiology and internal medicine in 1976 and who were still active in 1986. Disparities between men and women in rank attained were apparent in both specialties but were greater in radiology than in internal medicine. Other variables examined include ethnic-racial self-description and teaching, research, patient care, and administrative responsibilities. The authors pose additional research questions requiring information that the Faculty Roster System is not designed to provide. *Acad. Med.* 64(1989):198–202.

The increasing number of women graduating from medical school—which went from 700 in 1970 to 5,100 in 1987—is changing the composition of U.S. medical school faculties. In 1988 women held 19.3% of all full-time faculty positions (constituting 15.7% of all faculty that year with the M.D. degree and 21.4% of all those with other doctorates), up from 13.3% in 1968.[1] However, after rising from 4.8% in 1975 to 9.4% in 1986, the proportion of women who have attained the rank of professor has remained at 9.4%.[2] As Table 1 shows, the percentages of women at the ranks of associate professor and professor remain well below the percentages of men in these ranks.

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A survey of the faculties of diagnostic radiology departments revealed a profile similar to that shown in Table 1, with more women than men having the lower ranks (60% of men but only 29% of women were associate or full professors).[3] The same study found that women faculty published less and had less grant support than their male counterparts, but it found no sex differences in the percentages who were board certified, the average ages at the end of residency, or the hours spent teaching each week.

A study of academic anesthesiologists, using data from the Association of American Medical Colleges (AAMC) Faculty Roster System, found that fewer of the women were board certified and that the women's responsibilities differed from those of the men.[4] The women discussed in that study were principally engaged in teaching and patient care and less involved in research and administration. The women from the ages of 40 to 50 were heavily represented at the instructor level, and the women from the ages of 50 to 65 were heavily represented at the assistant professor level.

One study of career achievement among women physicians found only a single correlate of success among academic physicians: academic standing at the end of medical school. Although that study is limited in that it did not collect data on research, administrative, or teaching responsibilities, another of its findings may be relevant: marital status and number of children showed no consistent association with academic rank.[5]

Very few studies have yielded results that institutions and specialty societies could use in their attempts to encourage the advancement of women. A clearer picture is needed of the difference in the rates at which men and women move up through the academic ranks and the reasons for the difference. One way to clarify that picture is to compare the men and women in a cohort of faculty at a selected time following their first faculty appointments.

Method

The data used in this study were extracted from the AAMC Faculty Roster System, a computer data-base system containing information about

Table 1

Numbers and Percentages of Men and Women Faculty Members, by Academic Rank, at All U.S. Medical Schools, 1988*

Rank	Men		Women	
	No.	Percent	No.	Percent
Professor	15,285	31.5	1,094	9.4
Associate professor	12,535	25.8	2,307	19.8
Assistant professor	16,348	33.7	5,743	49.2
Instructor	3,348	6.9	2,032	17.4
Other	995	2.1	487	4.2
Missing	24	0.1	10	0.1
Total	48,535	100.0	11,673	100.0

*Data obtained from the Faculty Roster System data base of the Association of American Medical Colleges. Percentages are rounded.

the current appointments, employment histories, training, credentials, and demographic characteristics of current and former full-time salaried faculty at U.S. medical schools from 1966 to the present. The data are collected directly from the schools and are updated continuously. At any time the data-base contains information about approximately 80–90% of all active full-time salaried U.S. medical school faculty.[6]

For this project, the researchers used the data for current and former (inactive) internal medicine and radiology faculty who received their first appointments as medical school faculty in 1976 ($N = 1,379$). Internal medicine was selected for study because it has more faculty than any other specialty; radiology was selected because it is midrange among specialties in the number and percentage of residents who are women. In order to minimize the number of uncontrolled extraneous variables, the analysis of this group was limited to those faculty with M.D. degrees. This smaller group was the 1976 cohort of entering faculty ($n = 1,199$).

The following 17 variables were selected from the data base for use in this study:

- Department
- Rank (professor, associate professor, assistant professor, instructor, and other/unknown)
- Ethnic-racial category (American Indian, Asian, Black, Mexican-American, Puerto Rican, Caucasian)
- Sex
- Year of birth
- Year appointed to current position
- Year appointed to first medical school faculty position
- Type of doctorate (M.D., Ph.D., other, or none)
- Year of doctorate
- Teaching responsibility (not reported, reported, or reported as primary responsibility)
- Research responsibility (not reported, reported, or reported as primary responsibility)
- Patient care responsibility (not reported, reported, or reported as primary responsibility
- Administrative responsibility (not reported, reported, or reported as primary responsibility)
- Primary medical specialty
- Secondary medical specialty
- Active or deactivated status
- Year deactivated, if applicable

The variables dealing with areas of professional responsibility are derived from a question on the Faculty Roster questionnaire: "Check usual activities in which you spend at least 10% of your time annually. If a primary responsibility exists, enter 'P' in that category (only one box for 'P')." The question is followed by the following list: teaching/instruction; research; patient care (patient education); administration; other professional activities. A check mark in a box adjoining an item is interpreted as "reported" and a blank as "not reported."

Findings

The first question asked was whether in the 1976 entry cohort ($n = 1,199$) the women were more likely than the men to have dropped out of academic medicine. In departments of radiology and internal medicine, they were not: at the end of 1986, 47.4% of the women and 39.8% of the men in radiology were still active, and the corresponding figures for internal medicine were 50.7% and 49.3%. The difference between the sexes on these percentages was not statistically significant for either specialty.

Only the physicians who were active at the end of 1986 were included in the remaining analyses. In order to maintain maximum comparability and alleviate statistical problems associated with sparse and empty cells, it was necessary to eliminate from the analysis those holding the rank of instructor (16 internal medicine and four radiology faculty) and those who checked "other/unknown" in the "rank" category (one person in a radiology department). Thus, the total number of faculty in subsequent analyses was 546.

Table 2 depicts the distributions of academic rank, by sex and specialty, of the active 1976 entry cohort. This comparison clearly shows a disparity in rank attainment between the men and women at the end of their first 10 years on radiology and internal medicine faculties. The difference between the men and women is statistically significant for both specialties.

In order to compare the ethnic-racial compositions of the two specialties while avoiding problems of small cell size, it was necessary to collapse the ethnic-racial categories into "minority" (all but "Caucasian") and "nonminority ("Caucasian"). In de-

Table 2

Numbers and Percentages, by Academic Rank, of the 546 Men and Women in Internal Medicine and Radiology in 1986 Who in 1976 Had Attained the M.D. Degree and Received Their First Faculty Appointments*

	Men		Women	
Rank/Specialty	No.	Percent	No.	Percent
Internal Medicine†				
Professor	75	19.0	1	2.9
Associate professor	206	52.3	17	48.6
Assistant professor	113	28.7	17	48.6
Total	394	100.0	35	100.0
Radiology‡				
Professor	29	28.7	0	0.0
Associate professor	41	40.6	6	37.5
Assistant professor	31	30.7	10	62.5
Total	101	100.0	16	100.0

*Data obtained from the Faculty Roster System data base of the Association of American Medical Colleges. Percentages are rounded.
†Differences between men and women: chi-square was 9.03 with 2 df; $p < .05$.
‡Differences between men and women: chi-square was 8.61 with 2 df; $p < .05$.

partments of medicine, the women faculty of the 1976 entry cohort were significantly more likely ($p < .001$ based on a chi-square test) than the men to be members of minority ethnic or racial groups (32.4% of the women as compared with 10.2% of the men). In departments of radiology they were not (17.6% of the women as compared with 22.0% of men).

Although large majorities of both sexes in both radiology and medicine reported some teaching responsibilities, the women in internal medicine were significantly less likely ($p < .01$ based on a chi-square test) than the men to report such responsibilities (84.2% as compared with 95.5%). In radiology, the difference was reversed (96.0% of the men; 100% of the women) but not statistically significant.

In departments of medicine, the men and women of the 1976 cohort were about equally likely (75.5% of the men; 78.9% of the women) to report research responsibilities; the difference was not statistically significant. However, in radiology the difference was striking, with 71.3% of the men but only 44.4% of the women reporting research responsibilities ($p < .05$).

Large majorities of both sexes in both types of departments (90.1% of the men and 89.5% of the women in

Table 3

Numbers and Percentages of Internal Medicine and Radiology Faculty Physicians by Academic Rank Who in 1976 Had Attained the M.D. Degree and Received Their First Faculty Appointments, Reporting Their Research and Administrative Responsibilities in 1986*

	Research				Administration			
	Research		No Research		Administration		No Administration	
Rank/Specialty	No.	Percent	No.	Percent	No.	Percent	No.	Percent
Internal Medicine†								
Professor	67	20.6	8	8.0	44	22.3	31	13.5
Associate professor	185	56.7	37	37.0	104	52.8	118	51.5
Assistant professor	74	22.7	55	55.0	49	24.9	80	34.9
Total	326	100.0	100	100.0	197	100.0	229	100.0
Radiology‡								
Professor	23	29.5	6	16.7	11	35.5	18	21.7
Associate professor	35	44.9	10	27.8	12	38.7	33	39.8
Assistant professor	20	25.6	20	55.6	8	25.8	32	38.6
Total	78	100.0	36	100.0	31	100.0	83	100.0

*Data obtained from the Faculty Roster System data base of the Association of American Medical Colleges. Percentages are rounded.
†Differences between academic ranks: for research, chi-square was 38.94 with 2 df; $p < .001$; or administration, chi-square was 8.23 with 2 df; $p < .05$.
‡Differences between academic ranks: for research, chi-square was 9.70 with 2 df; $p < .005$; for administration, chi-square was 2.74 with 2 df; $p > .05$.

internal medicine, 97.0% of the men and 94.4% of the women in radiology) reported having some patient care responsibilities. The differences between the men and women were not statistically significant.

With regard to administrative responsibilities, the pattern resembles that seen with regard to research responsibilities. The men-women difference is small (46.0% of the men versus 44.7% of the women) and not statistically significant for those in internal medicine but quite noticeable for those in radiology (29.7% of the men compared with 5.6% of the women—$p < .05$).

Table 3 shows the overall relationship in 1986 between academic rank and research responsibilities and between rank and administrative responsibilities, without regard to sex. Research responsibilities were significantly associated with higher rank in both radiology and internal medicine. Administrative responsibilities were significantly associated with higher rank in departments of internal medicine but not in radiology departments.

Discussion

This analysis discloses for one cohort of active physicians the differences between men and women in rank attained 10 years after their first appointments to a medical school faculty, showing that the disparities were greater in radiology than in internal medicine. The study also affirms that research responsibilities were associated with the attainment of higher academic rank. In internal medicine but not in radiology, administrative responsibilities were also found to be associated with higher rank. Given the larger overall percentage of internal medicine faculty reporting administrative responsibilities, this difference between the specialties with regard to promotions is not altogether surprising.

In radiology but not in internal medicine, the men studied were much more likely than the women to report both research and administrative responsibilities; this disparity probably accounts for the greater rank disparities between the sexes in this specialty than in internal medicine. In internal medicine, however, even though the same percentage of men and women reported research responsibilities, differences in the ranks attained are evident. The limits of the AAMC Faculty Roster System as a source of data on research activities make it difficult to explore the implications of this finding. The only national study of research activities of medical school faculty was a joint effort of the AAMC and the Association of Professors of Internal Medicine and was limited to departments of internal medicine.[7] An unpublished analysis of these responses classified by sex showed that the women had less formal preparation for research, less laboratory space assigned to them, and less overall research involvement than the men.[8]

A comparative profile of the research and other activities of women and men faculty that relies only on AAMC Faculty Roster data is necessarily limited. More studies are needed to achieve a better understanding of the lag in women's advancement in academic medicine. Many questions should be addressed; for example:

1. Are women less interested in research than men? Data from the AAMC's survey of 1987 graduating seniors[9] reveal very little difference; during medical school 43% of the women and 46% of the men were investigators on research projects; 19% of the women and 24% of the men authored published research papers. Moreover, in 1987 as great a proportion of women as men predicted research fellowships for themselves during graduate medical education. Will influences later in their careers deter women from pursuing research interests with the same determination as men?

2. Are women faculty acquiring the information and guidance from mentors necessary to plan successful careers in academic medicine? How can information networks for women faculty be improved? Given the scarcity of women who can serve as mentors, can ways be found to help men provide more effective guidance to women?

3. What characteristics of the academic value system need to be examined vis-à-vis the advancement of women? Are women disproportionately attracted by tracks that emphasize clinical teaching over bench research for promotion, such as the clinician-educator tracks that exist at some institutions? Are "stop-the-clock" programs, allowing faculty to postpone tenure decisions, helpful to women in academic medicine?

4. How can deans and department chairmen be encouraged to address the differential between men's and women's rates of academic advancement?

The analysis offered in this paper is only a small part of the research needed if the questions surrounding the advancement of women in academic medicine are to be answered.[10] The scientific community has led the way in studies of sex differences in the careers of scientists and engineers,[11] and the representation of women in the higher echelons of academic science is receiving increasing notice.[12,13] This attention and research may provide some valuable pointers for the study of women's career development on medical school faculties.

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Survey Results and a Recommendation for a Change in U.S. Medical Physiology Curricula

RONALD D. CARLIN, Ph.D.

Abstract—Both the recent advances in molecular biology and the dilemma of teaching a larger volume of more detailed material to students from a declining, weaker applicant pool necessitate a critical reappraisal of the medical physiology curriculum and pedagogy. An extensive survey of the physiology curricula in 107 U.S. medical schools conducted during the 1986-87 academic year revealed that physiology was taught as a separate course, averaging 100.1 lecture hours, 24.0 laboratory hours (usually dealing with cardiovascular and pulmonary physiology), and 25.6 conference hours. The physiology courses offered by the schools surveyed averaged 21.8 weeks in duration and were taught by an average of 13 faculty (72.5% with Ph.D. degrees, 21.8% with M.D. degrees, and 5.4% with both M.D. and Ph.D. degrees). The evolution of the physiology curriculum has been slow; as a result the need for change is great. Physiology departments must give a high priority to reorganizing and revitalizing teaching. Additionally, the physiology curriculum must be critically examined. There is an urgent need to reevaluate course content, decide the fate of the student laboratory, and develop new, innovative teaching techniques. The ubiquity of these problems among medical schools suggests that they be addressed at a national level. *Acad. Med.* 64(1989):202-207.

Physiology, by definition, is the study of the body's functions. Therefore, physiology logically serves as an infrastructure upon which numerous other disciplines build[1]—for example, pharmacology (how chemical agents modify function), pathology (how disease states alter function), and medicine itself (the study of normal and abnormal human physiology). Physiology has been described by students and faculty in both basic and clinical sciences as one of the most, if not the most, clinically relevant basic science.[2]

The face of physiology is changing as the understanding of body functions is resolved at the cellular level and, in some cases, the molecular level. Physiology must merge and integrate with molecular biology in order to remain at what has been called the "cutting edge" of the biomedical sciences.[3] The alternative is that physiology will become a stagnant pool of knowledge or a kind of "gross anatomy of the 1980s."[3]

Assuming that physiology and molecular biology can be appropriately integrated, a new problem arises: given the limitations of an already overcrowded four-year medical curriculum,[4,5] how do faculty convey to their students a significantly expanded knowledge base, encompassing the most current level of understanding at a cellular level, without compromising the crucial need to foster an appreciation of "classical" organ-system physiology?[6] Certainly, some degree of understanding of the body function at each organizational level is required.[7] Will attempts to squeeze an expanded knowledge base into a shrinking time slot allotted for the physiology curriculum necessitate the complete elimination of an already compromised student labora-

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tory and thereby completely expunge the already minimal hands-on approach to learning and the practical reinforcement of physiological principles? The future of the medical physiology curriculum is complicated still further as various organ systems or topics are gradually removed from the physiology course, either to be taught as parts of courses in other basic sciences or clinical disciplines or to be developed into separate curricular entities. Overlying all of this is the added handicap that the student applicant pool seems to be declining in both number and academic ability.

In the face of such pressing issues, it is obvious that more attention must be paid to the development and evolution of the medical physiology curriculum. The study described here was undertaken to generate a precise up-to-date picture of the medical physiology curriculum that will allow schools to compare their physiology programs with the average curriculum. Equally important, it will permit assessment of the status of the medical physiology curriculum from a nationwide perspective and, as a result, provide a basis upon which to evaluate how that curriculum needs to be modified or, if necessary, redesigned.

Method

A three-page questionnaire was designed to obtain data from various types of human physiology curricula (for example, those in medical, dental, graduate, nursing, and other programs). Topics addressed by the questionnaire included general curriculum organization, as well as content, duration, and topic emphasis for the lecture, laboratory, and conference components of the curriculum. In addition, data were collected on faculty (numbers, backgrounds, and lecture responsibilities), examinations (number, types of questions, and grading system), and the use of teaching adjuvants (such as printed notes, computers, and textbooks). Last, a portion of the questionnaire contained opinion questions to determine what physiology educators believed to be the optimal physiology curriculum.

Questionnaires were sent in early August 1986 to members of the Association of Chairmen of Departments of Physiology (ACDP). Chairpersons (or through their offices, the appropriate supervisory faculty or program directors) were requested to complete a questionnaire for each comprehensive, or organ-system, course being taught by the faculty. The ACDP membership at that time consisted of 151 chairpersons or physiology program directors. Questionnaires were mailed to 148 ACDP members (136 from the continental United States, 11 from the remainder of the Northern Hemisphere, and one from Hawaii). Of the forms coming from within the continental United States, 107 (approximately 79%) were from medical school physiology departments.

Those individuals who did not respond to the initial mailing were sent a second form in mid-October 1986. In those instances in which there was no response to the second mailing, the chairperson was contacted late in 1986 or early in 1987 and urged to participate. Data from the questionnaires were tabulated and statistically analyzed employing a computer and a standard statistical software package.

In some instances the returned forms contained unanswered questions. Whenever feasible, the voids were filled after telephone conversations with representatives of the institutions involved. In the calculation of mean values, values of zero, assigned when a particular component was not present in the physiology curriculum, or there was no reply to a specific question, were not included.

Results

A survey response rate of approximately 90% was achieved. The responses consisted of 191 forms returned from 131 institutions. Of the 191 forms completed, 56.8% (111 questionnaires from 107 medical schools within the continental U.S. and two Canadian, one Puerto Rican, and one Mexican medical school) pertained to medical school physiology curricula. The data presented here are confined to the responses from the 107 U.S. medical schools, which constituted 86.3% of the 124 medical schools in the continental United States at that time. Accordingly, the data should accurately reflect the U.S. medical school physiology curriculum at that time.

Of the 107 medical schools responding, 92 (86%) taught physiology as a separate course, and nine schools taught it as part of an organ-system approach. The remaining six schools taught it in some other curricular format, this most often being a hybrid in which some areas were taught in separate courses and other areas were presented as parts of an integrated, or organ-system, approach.

Lectures

The survey showed that the average medical physiology curriculum contained 100.1 (SD = 39.5) lecture hours, with 76% of the 107 respondents indicating that their physiology curricula contained sufficient numbers of lecture hours. Among the remaining 24%—those that indicated that their programs contained insufficient numbers of lecture hours—there was no consensus as to which specific areas or topics should be given more time. Sixty-three percent of the respondents reported that the number of lecture hours had remained constant over the previous five years; however, 27.1% noted a decrease in lecture hours. Only 9.3% of the programs had experienced an increase in lecture hours over the five-year period.

As shown in Table 1, the individual schools did not necessarily have all of the traditional organ-system topics within their physiology curricula. Only cardiovascular, pulmonary, and gastrointestinal physiology were present in all of the physiology curricula. The remaining topics, with the exception of central nervous system (CNS), physiology were incorporated in 80.1–99.1% of the physiology programs.

Only 59.3% of the programs included CNS physiology; however, when present it was the component

Table 1

Percentages of 107 U.S. Medical Schools Teaching Each of Nine Topics in Classroom, Laboratory, and Conference Formats, and Average Durations and Average Percentages of Total Time Devoted to Each Topic in Each Format, 1986–87*

	Classroom Format			Laboratory Format			Conference Format		
Physiology Topic	Percentage of Schools	Average Duration (hours)	Percentage of Total Time	Percentage of Schools	Average Duration (hours)	Percentage of Total Time	Percentage of Schools	Average Duration (hours)	Percentage of Total Time
Cardiovascular	100.0	19.4	20.1	75.0	8.8	41.9	75.0	5.7	25.9
Respiration	100.0	12.4	12.8	67.6	5.1	24.7	70.4	3.9	16.7
Renal	99.1	11.3	11.7	38.9	4.8	13.9	69.4	3.9	15.3
Endocrine	89.8	16.6	16.5	14.8	6.9	12.5	57.4	4.8	17.3
Gastrointestinal	100.0	9.6	10.2	20.4	3.9	11.3	53.7	3.0	12.2
Membrane/cell	88.9	7.5	7.5	32.4	4.6	18.1	48.1	3.2	10.6
Neuromuscular	89.8	6.8	6.6	34.3	4.8	18.6	47.2	2.7	9.6
Acid-base	80.1	3.9	4.0	12.0	3.1	8.7	38.0	1.8	8.1
Central nervous system	59.3	19.6	14.2	22.2	8.5	20.1	25.9	6.2	13.8

*Data taken from a survey of members of the Association of Chairmen of Departments of Physiology; 107 of the respondents were from U.S. medical schools.

that was assigned the most lecture time with an average of 19.6 lecture hours devoted to it. Though it had the longest average lecture duration, CNS physiology ranked third in terms of the average percentage of the total curricular time devoted to any topic in the medical school physiology programs (14.2%). Cardiovascular physiology, the component with the second-longest average duration (19.4 hours), occupied the largest part of the physiology curriculum (20.1%). The reason for this apparent paradox is that those physiology programs that included a CNS section were, as a result of its inclusion, of longer duration. Because the CNS section was a segment of longer programs, it represented a smaller fraction of total program duration. Cardiovascular physiology was present in all programs; in shorter physiology programs (schools with a separate neuroscience course and no CNS physiology section), it constituted a larger percentage of the total duration.

In addition to the major organ systems, most schools (73.2%) included in the physiology curriculum at least one additional lecture topic, with many schools (40.7%) having two, and some (7.4%) incorporating three other topics. Thirty-three different topics of this kind were recorded. The five most frequently cited and the frequencies with which they were mentioned were temperature regulation (21.8%), exercise physiology (17.3%), metabolism (9.6%), reproductive physiology (9.6%), and integrative physiology (6.4%).

With respect to the integration of molecular biology into the medical curriculum, 14.5% of the responding institutions indicated that it was included as part of physiology, 24.1% presented it as a separate course (averaging 75.5 hours), and 61.4% incorporated the material into one or more of the other basic science disciplines. Where molecular biology was included as a part of a single basic science other than physiology, that science was most often biochemistry; when molecular biology was presented in conjunction with two or more disciplines, these were most frequently biochemistry and histology.

Laboratory

Though almost all the responding medical schools (87.4%) indicated that the student laboratory was a necessary component of a physiology curriculum, 46.5% of the institutions reported a decrease in the number of laboratory hours over the previous five years. Only 4.0% reported an increase over the same period. While the laboratory component was generally shrinking, most schools (67.9%) indicated that their physiology curricula contained sufficient laboratory time. Approximately 25% of the responses cited a need for additional laboratory time, indicating that an additional 13.7 (SD = 9.5) hours would be necessary. While only 24.3% of the responding institutions used computer-simulation laboratory exercises, approximately two-thirds of the medical schools reported having some form of human laboratory exercise and one or more animal experiments. Of the schools that used animals in the student laboratory, 84.4% used dogs.

Table 1 includes the percentages of schools having one or more laboratory exercises devoted to each organ system, the average total duration of the laboratory exercise or exercises related to that organ system, and the percentages of the total laboratory time devoted to each organ system. As evidenced in the table, only two topics had a related laboratory exercise or exercises in the majority of U.S. medical schools surveyed. Cardiovascular laboratories were conducted in 75.0% of the schools, had an average duration of 8.8 hours, and accounted for 41.9% of the total laboratory time; respiratory laboratories were taught in 67.6% of the schools, had an average duration of 5.1 hours, and occupied 24.7% of the total laboratory time. Exercises dealing with the central nervous system were presented in only 22.2% of the medical schools; however, where they were

conducted, on average these exercises accounted for 20.1% of the total laboratory time and had a duration of 8.5 hours.

Conferences

The numbers of the responding medical schools that had allotments of time devoted to individual organ systems (see Table 1) varied over a wide range, extending from 75.0% for cardiovascular physiology to 25.9% for CNS physiology. Predictably, cardiovascular conferences constituted the largest portion of the total conference time (25.9%) and had the second longest total duration (5.7 hours). When present in the curriculum, CNS physiology conferences had the longest average duration, 6.2 hours. The average total curricular conference time was 25.6 (SD = 23.8) hours.

Examinations and Grading

The average medical physiology program contained five examinations, with the final examination in most programs (71.4%) being cumulative. Examinations most frequently consisted of multiple-choice questions. The types of questions and the percentage of programs employing each type were multiple-choice, 91.0%; computational questions, 52.3%; multiple-multiple choice (that is, questions accompanied by four or five possible answers that can be used in varying combinations; for example, answer "A" if choices 1 and 3 are correct, answer "B" if choices 2 and 4 are correct, etc.), 45.0%; true-false, 37.8%; essay, 31.5%; fill-in-the-blank, 27.0%; case studies, 21.6%; other forms, 18.0%; and oral examinations, 3.6%.

While the majority of programs (80.4%) indicated that they used "national-board-type" questions, only 24.3% of the respondents indicated that the national boards influenced the content or weighting of topics in their programs. In terms of student grades, schools were almost equally divided between letter or number grades (44.0%) and pass or fail grades (46.8%), with the remaining schools (9.2%) implementing a hybrid form of grading that can best be described as an expanded pass or fail system (for example, honors, high pass, pass, and fail). Of the physiology curricula that had a laboratory component, 56.8% did not administer any laboratory grade, 38.3% incorporated the laboratory grade as a portion of the student's final grade, and 4.9% had a separate laboratory grade.

Faculty

The average medical physiology curriculum had 13 participating lecturers; 72.5% of them held Ph.D. degrees, 21.8% held M.D. degrees, and 5.4% held both. Approximately 75% of the faculty held appointments in physiology, with the remainder being drawn from other disciplines. Most frequently, those faculty were from medicine (34.3%), surgery (10.3%), obstetrics and gynecology (10.3%), pediatrics (8.6%), and neurology (8.0%). Ninety-five schools cited their average numbers of lecture hours per instructor; the mean value of these responses was 10 hours. Twenty-four schools also listed the greatest and least numbers of lecture hours per instructor; values ranged from a low of one to a high of 74 hours.

Instructional Resources

Printed notes were used in most physiology programs (75.5%), as were videotapes (67.9%), whereas computers had been adopted in only 40.4% of the schools. In those schools where computers were employed, the majority (60%) used them for laboratory stimulations; in the remaining programs they served as a mechanism for study enhancement or student self-assessment. Most (83.6%) of the programs that did not use computers indicated that they planned to adopt them.

Approximately 70% of the medical schools surveyed required the students to purchase one or more texts. Within that population of schools, 66.6% required a single comprehensive text, 16.7% required a series of monographs, and 16.7% required a comprehensive text plus one or more monographs. Among the comprehensive texts, the Guyton textbook[8] and the Berne and Levy book (first edition)[9] were equally popular as a single required text (22.2% of the schools using each). However, when considering texts used in combination with monographs, the Guyton textbook had a slight edge (5.6% versus 4.2%). Eighty-six percent of the physiology programs recommended the purchase of one or more books by the students. The comprehensive text most frequently recommended, either by itself or in combination with one or more monographs, was the Best and Taylor text edited by West.[10]

The Optimal Curriculum

In a series of opinion questions, the respondents described what they considered an optimal physiology curriculum. The data obtained from these questions showed the optimal numbers of lecture and laboratory hours to be 106.5 and 42.4, respectively, with an optimal curriculum duration of 22.1 weeks. These values, when compared with the actual values of 100.1 and 24.0 hours and an average curriculum duration of 21.8 weeks, show close agreement.

Discussion

Progressive educators have for some time advocated the organ-system approach to facilitate integrative learning in the medical curriculum. Despite this, it appears that medical physiology is still being taught in a traditional manner, that is, as a separate course (86% of the responding schools), with formal lectures being the principal teaching method.

Medical physiology curricula vary considerably in content and duration, as shown by the large standard deviations in some of the data. Lecture content varies, as is apparent in Table 1. Only three organ systems were common to all the programs surveyed. Where an organ system or topic was not included in the physiology course of instruction, it was incorporated in some other segment of

the medical curriculum or, in some cases, topics from the physiology curriculum had evolved into separate, distinct curricular entities.

An example of this type of evolution is molecular, or cell, biology: 24.1% of the schools indicated that that subject was presented as a separate course. This was also the case with CNS physiology, which accounts for the fact that only 59.3% of the programs devoted a block of time to this topic. Because CNS physiology entails a substantial amount of material, it is not surprising that it would have the longest average duration and thus generally be a component of longer physiology curricula. This explains why CNS physiology, as compared with cardiovascular and endocrine physiology, constituted a smaller average fraction of the total lecture time devoted to any one topic.

Clearly, the laboratory component of the medical physiology curriculum is waning. The average total laboratory time reported was 24.0 (SD = 20.0) hours, which constitutes more than a 67% decrease from the 73 hours reported in 1975.[11] Almost half (46.5%) of the responding institutions reported undergoing a reduction in student laboratory time over the previous five years, and only 4.0% reported having an increase.

In most of the schools surveyed, laboratory time was largely devoted to human studies and animal experiments (65.8% and 63.1%, respectively). With respect to the animal laboratories, 84.4% of the programs indicated that dogs were used for one or more laboratories. This finding is surprising in view of the prominent and controversial animal rights issue as well as the soaring cost of animals (even those that are unconditioned).

It is worth noting that only 24.3% of the physiology programs used computer-simulation exercises in their laboratories. This number can be expected to grow significantly, since the vast majority (83.6%) of the schools not employing computers planned to adopt them. Additionally, the development of more software, increased availability of software through sharing programs, declining computer costs, and the attrition of senior, more traditional faculty who are reluctant to implement computers all favor increased adoption of computers.

Although laboratory exercises using computer simulations have many drawbacks, they do have one distinct advantage: they may be performed during the student's unstructured time. For this reason, they also offer enormous potential as a study enhancer, especially in those areas of physiology that involve explanation of principles through problem-solving. The use of computers (and other audiovisual media) in this manner can significantly increase the active learning process; that is, these tools allow students to participate actively in the learning process, with the only limiting factor being the availability of software.

A review of Table 1 shows that the organ systems may generally be divided into three categories: those to which most physiology programs (approximately 70–75%) have devoted some laboratory time, those to which a moderate number of programs (20–40%) have devoted laboratory time, and those to which few programs (10–15%) have dedicated any time. The cardiovascular and respiratory systems, appropriately, fall into the first category. These systems are well suited for student laboratory exercises because they respond rapidly to any stimulation and also represent some of the more difficult and quantitative subject matter. Respiration is an especially fitting laboratory topic because it lends itself to human studies. At the opposite end of the spectrum, endocrine physiology and acid-base balance are not particularly well suited to study in the student laboratory, nor are they conceptually difficult; thus, laboratory experiences would not significantly aid student understanding in these areas.

Implications

The findings of this survey concerning the optimum physiology curriculum reveal a good correlation with the existing curricula. Despite this, the issues reviewed at the beginning of this article make it clear that the structure and content of the medical physiology curriculum require revision. Yet little regular, systematic examination of content is occurring.[12]

Moreover, the quality of physiology instruction must be scrutinized. In previous years, many faculty in physiology education, like faculty in most other fields, viewed their teaching responsibilities as a necessary chore,[13] especially since universities have tended to value research more than teaching. But for some time a small group of physiologists has been urging that attention be paid not only to what is taught and how it is taught but also to the quality of instruction.[14,15] In the final analysis, the success of any curriculum depends on the extent to which the instructors are committed to making the program work well.[16] This need to ensure excellent instruction is, unfortunately, not limited to physiology or medicine —inadequacies in instruction permeate undergraduate programs in many fields nationwide. The result has been a recent call by university presidents for better teaching and a reiteration that "teaching is the first business of our universities."[17]

Reforms in both the content and the pedagogy of physiology have been advocated for many years.[18,19] It is not too late to take such recommendations seriously, and the need to do so has become urgent. Change in physiology teaching is crucial to the future of medical education, because physiology is the apex of the pyramid of the basic sciences and at the same time the foundation of the pyramid of the clinical sciences. As Claude Bernard noted, "physiology is the basis of all medicine."[20]

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A Review of Medical Education and Medical Informatics

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Abstract—Physicians have considerable difficulty collecting and interpreting information from patients, dealing with the uncertainties associated with diagnosing and treating their patients, communicating precisely with one another, keeping up to date, and applying recommended procedures when indicated. Some of the advances in information technology may help physicians to manage information more effectively through more accessible, validated clinical indexes, data bases of diagnostic test characteristics, computerized audits of clinical activities with feedback, expert systems, on-line access to the medical literature, and other tools of medical informatics. Medical educators can catalyze this process by facilitating the introduction of information technology into academic clinical settings so that students can learn its use firsthand and by promoting the evolution of this and other aspects of medical informatics, a new discipline dedicated to the solution of information problems in health care. The potential roles for computer-aided instruction and centralized computer laboratories in medical schools are much less clear. *Acad. Med.* 64(1989):207-212.

This paper is based on a presentation for the Conference on Medical Education and Cost-Effective Health Care, sponsored by the Rockefeller Foundation and the World Health Organization, at the Bellagio Conference Center, Bellagio, Italy, March 21-25, 1988.

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The next decade will be both agonizing and exhilarating for those committed to achieving cost-effective health care. On the one hand, biomedical science has spawned an astonishing array of genuine advances in health care that can prevent disease, save lives, reduce disability, and relieve suffering. On the other hand,